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COMPARATIVE ASSESSMENT OF THE EFFECTIVENESS OF OSTEOPLASTIC MATERIALS IN DIRECTED BONE REGENERATION

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Abstract: The work conducted a comparative assessment of the effectiveness of three osteoplasty methods used for targeted bone regeneration of the alveolar ridge: synthetic hydrogel composite S1, combination of S1 with autologous PRF, and complex A-Oss + I-PRF + Colla D. The study included 67 patients with II-III-degree alveolar ridge atrophy. The results were evaluated based on clinical, radiological, and morphological criteria, including bone tissue growth, regenerate resorption, bone density, mineralization timing, vascularization, and the frequency of successful osseointegration. It has been established that combined methods using growth factors provide more pronounced bone growth, reduced resorption, and improved vascularization and osteointegration indicators compared to the use of a single osteoplastic material.

Keywords: targeted bone regeneration; osteoplastic materials; S1; PRF; I-PRF; A-Oss; Colla D; bone density; osteointegration; alveolar ridge.

Introduction Alveolar ridge atrophy is one of the main causes of dental implantation difficulties. The targeted bone regeneration (TCR) method is based on the use of osteoplastic materials and barrier membranes that contribute to the formation of a new bone volume and the isolation of the defect from soft tissues. Material S1 is a synthetic composite based on β-tricalcium phosphate and hydroxyapatite, having a hydrogel structure that ensures plasticity, self-fixation, and shape retention without membranes. This eliminates the risk of material displacement and reduces the trauma of the intervention. To enhance biological activity, autologous growth factors are used, specifically PRF (Platelet-Rich Fibrin) and its injectable form I-PRF, which stimulate angiogenesis and osteoinduction. The classic A-Oss material requires the use of Colla D collagen membrane, which stabilizes xenogenic granules and prevents displacement.

Thus, it is relevant to compare three methods:

- hydrogel osteoplast S1,
- its combinations with PRF,
- and the complex system A-Oss + I-PRF + Colla D.

Purpose of the research

Conduct a comparative clinical and morphological assessment of the effectiveness of osteoplastic materials S1, S1 + PRF and A-Oss + I-PRF + Colla D in targeted bone regeneration based on the radiological, morphological, and clinical quality indicators of the newly formed bone.

Materials and methods. Type of study: prospective clinical and morphological. Number of patients: 67 (38 women, 29 men), aged 30-65 years. Inclusion criteria: Seibert II-III-degree alveolar ridge atrophy, absence of inflammatory processes, indications for dental implantation.

Group distribution

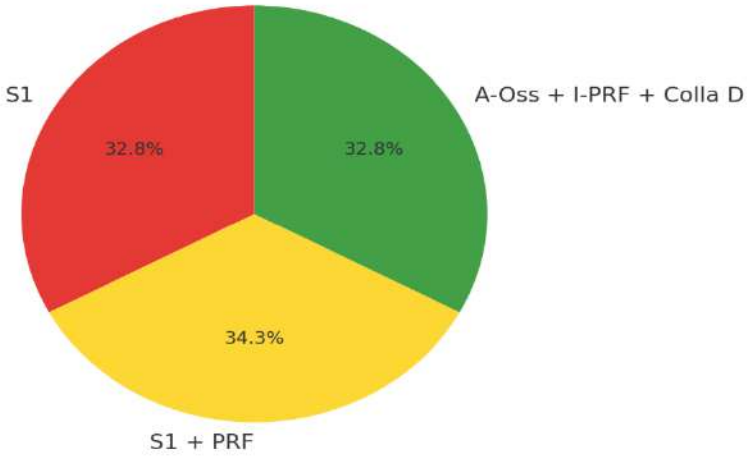


Diagram of the use of osteoplastic materials in directed bone regeneration (S1, S1 + PRF, A-Oss + I-PRF + Colla D).

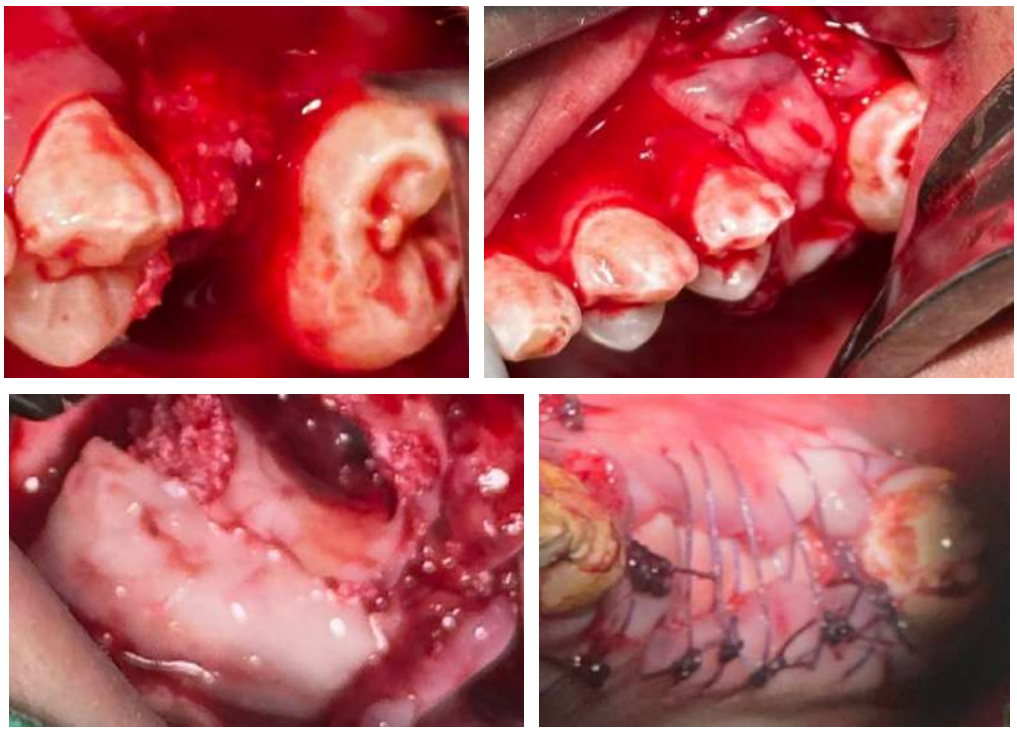


Figure 1. Operations stages

Evaluation methods

- Clinical: healing dynamics, inflammatory reaction, membrane exposure.
- Radiological (LCT): bone tissue growth (mm), density (HU), resorption (%).
- Morphological: osteoid maturity, osteocyte density, vascularization (0-3 points).
- Statistics: ANOVA, $p < 0.05$.

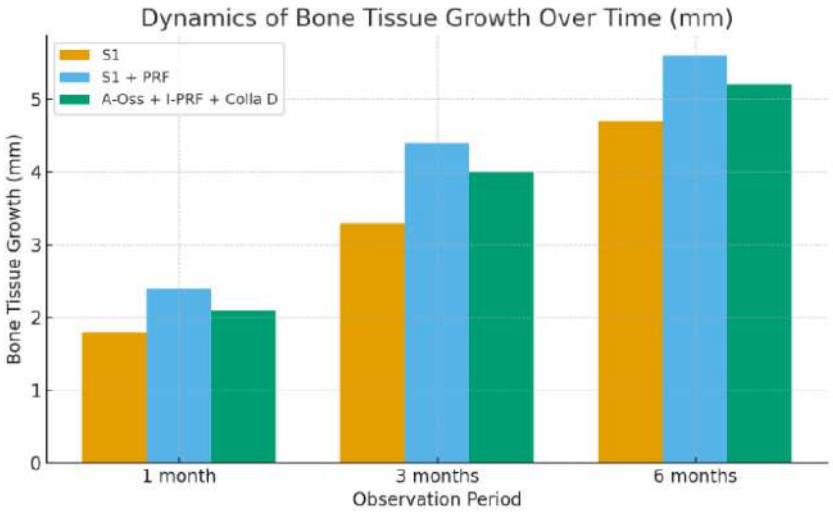
Results

Table 1. Comparative Indicators of GBR Effectiveness

Indicator	S1	S1 + PRF	A-Oss + I-PRF + Colla D	p < 0.05
Bone gain (mm)	4.7 ± 0.5	5.6 ± 0.4	5.2 ± 0.4	+
Resorption after 6 months (%)	5.5	3.8	4.3	+
Bone density (HU)	940 ± 85	1025 ± 70	1010 ± 75	+
Mineralization time (months)	4.4	3.5	3.9	+
Vascularization (0–3 score)	2.5	2.9	2.8	+
Successful osseointegration (%)	93.1	97.6	96.4	+

The table presents a comparative analysis of the effectiveness of three osteoplasty methods: S1, S1 in combination with PRF and A-Oss with I-PRF and collagen membrane. For each methodology, indicators characterizing the quality of bone regeneration are presented: bone tissue growth, the degree of resorption after six months, the density of the formed bone, the timing of mineralization, the severity of vascularization, and the frequency of successful osseointegration. It was shown that the differences between the groups are statistically significant at a level of $p < 0.05$.

Diagram of bone tissue growth dynamics over time (mm)



The diagram illustrates the dynamics of bone tissue growth in millimeters when using three different osteoplasty methods (S1, S1 + PRF and A-Oss + I-PRF + Colla D) during the observation period. At the first time point, corresponding to one month, each method demonstrates a different degree of bone tissue formation, with values ranging from minimal increase in standard material to more pronounced growth when using combined methods.

At the second and third time points, corresponding to three and six months of observation, the diagram reflects the gradual increase in the volume of formed bone in all studied groups. Bone tissue growth increases from one period to another, and for each methodology, a characteristic dynamic of indicator change is observed. At the final observation stage, each methodology demonstrates maximum growth values compared to previous periods.

Table 2. Dynamics of Bone Tissue Growth (mm) Over Time

Observation Period	S1 (mm)	S1 + PRF (mm)	A-Oss + I-PRF + Colla D (mm)
1 month	1.8 ± 0.2	2.4 ± 0.2	2.1 ± 0.3
3 months	3.3 ± 0.4	4.4 ± 0.3	4.0 ± 0.4
6 months	4.7 ± 0.5	5.6 ± 0.4	5.2 ± 0.4

The table reflects the dynamics of bone tissue growth using three osteoplasty methods - S1, S1 in combination with PRF and A-Oss with I-PRF and collagen membrane - during three observation periods. In the first month, in all groups, the initial formation of a new bone volume is noted, differing in the degree of severity depending on the applied material. By three months, further bone tissue growth is observed in all methods, with combined approaches showing higher values compared to using only S1. At the sixth month, maximum bone tissue growth is recorded in all groups, indicating continuous regeneration throughout the observation period.

Discussion. The research results demonstrate pronounced differences in bone regeneration quality between the studied methods. The use of S1 hydrogel composite ensures the formation of a stable regenerate due to its plasticity and ability to retain the shape of the defect without applying a membrane. However, the inclusion of autologous growth factors in the form of PRF and I-PRF enhances regenerative potential, which is confirmed by increased bone tissue growth, accelerated mineralization, and increased regenerate density. Higher vascularization in the S1 + PRF group indicates stimulation of angiogenesis, providing improved conditions for osteoid maturation.

The complex method of A-Oss + I-PRF + Colla D demonstrates comparable results with the combination of S1 + PRF, which is due to the stability of the xenogenic material and the support of the granules by the collagen membrane. However, the need to use a membrane increases the trauma of the procedure and the risk of exposure. At the same time, the indicators of successful osseointegration in both combined methods exceed the results of the S1 group, which confirms the influence of growth factors on the intensity and quality of bone remodeling.

Statistically significant differences in key parameters ($p < 0.05$) indicate that the biological activity of osteoplastic materials increases with the inclusion of PRF technologies. These data are consistent with the results of foreign studies indicating the synergistic effect of platelet concentrates and osteoplastic materials under RCP conditions.

Conclusion. All the studied methods of targeted bone regeneration ensured the formation of a new bone volume, however, the severity of regeneration differed between the groups.

Combinations of osteoplastic materials with PRF and I-PRF demonstrate a significant increase in bone growth, higher regenerate density, lower resorption, and better vascularization compared to the use of a single material.

The S1 + PRF and A-Oss + I-PRF + Colla D methods provided the highest indicators of successful osseointegration, which emphasizes the role of growth factors in stimulating osteogenesis.

Material S1 due to its hydrogel structure has ease of application and self-fixation, however, its effectiveness increases when combined with PRF.

The obtained results confirm the feasibility of using PRF-technologies in complex RCT to improve the quality and stability of bone regeneration.

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